EXPLORATIONS
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Predicting Scientific Prediction — **BARRINGTON NEVITT**

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PREDICTING SCIENTIFIC PREDICTION

Definitions reflecting, or imposed upon, science The Oxford English Dictionary gives some generally accepted definitions for "science" and says in part:

Systematic and formulated knowledge (moral, political, natural, etc.) . . . organized body of knowledge that has been accumulated on a subject . . . exact science, *admitting of quantitative treatment*; pure science, *one depending on deductions from self-evident truths, or mathematics, logic;* natural, physical science, *one dealing with material phenomena and based mainly on observation, experiment, and induction, as chemistry, biology . . .*

However, scientists are continually redefining "science" through what they are actually doing every day. Charles Singer tells us that:

History has repeatedly shown that a body of scientific knowledge that ceases to develop soon ceases to be science at all. The science of one age often becomes the nonsense of the next . . . Science, then, is no static body of knowledge but rather an active process *that can be followed through the ages . . . By derivation* scientific *implies* knowledge making, *and no body of doctrine which is not* growing, *which is not actually* in the making, *can long retain the attributes of science.*

Charles Singer, *A Short History of Scientific Ideas to 1900*
(Oxford, Clarendon Press, 1959), p. 1, and p. 2.

Let us therefore concede that science is an active, continuing, knowledge-making, and knowledge-testing process. No static definition can reflect its dynamic actuality.

Aims of scientists, past and present What was Newton's chief goal in 1687? *Absolute mechanical determinism*, or as he says:

I wish I could derive all phenomena of nature, by some kind of reasoning from mechanical principles.

Singer, *A Short History* . . . , p. 1.

In 1814 Laplace also clearly expressed this ideal in his oft-quoted statement:

We ought then to regard the present state of the universe as the effect of its anterior state and as the cause of the one which is to follow. Given for one instant an intelligence which could comprehend all the forces by which nature is animated and the respective situation of the beings who compose it — an intelligence sufficiently vast to submit these data to analysis — it would embrace in the same formula the *movements of the greatest bodies of the universe and those of the lightest atom; for it, nothing would be uncertain and the future, as the past, would be present to its eyes.*

Marquis de Laplace, *A Philosophical Essay on Probabilities*
(New York, Dover, 1952), p. 4.

Most leading scientists of the mid-twentieth century, however, no longer consciously defend this position. For example, P. A. M. Dirac believes that:

> . . . *nature works on a different plan. Her fundamental laws do not govern the world as it appears in our mental picture in any very direct way, but instead they control a substratum of which we cannot form a mental picture without introducing irrelevancies.*

P. A. M. Dirac, *The Principles of Quantum Mechanics*
(Oxford, Clarendon Press, 1958), preface.

Moreover, Dirac continues:

> . . . *the main object of physical science is not the provision of pictures, but is the formulation of laws governing phenomena and the application of these laws to the discovery of new phenomena. If a picture exists so much the better . . . One may, however, extend the meaning of the word "picture" to include any* way of looking at the fundamental laws which makes their self-consistency obvious.

Dirac, *The Principles* . . . , p. 10.

The chief barriers to advance in today's physical sciences are, therefore, no longer due to conscious acceptance of Newtonian and Laplacian goals. Nonetheless, physical scientists have yet to find satisfactory theoretical models, not only to ensure freedom from the unconscious bias of mechanical determinism, but more particularly to prevent other hidden biases from obstructing exploration and discovery.

Laws governing, or derived from nature In discussing philosophical assumptions underlying physical sciences, Milič Čapek remarks that:

> . . . *the closest connection between strict determination and the corpuscular-kinetic model of nature can be seen from the very form in which the deterministic belief was stated given a state of the universe at a given instant . . . all the states of the cosmic history, whether past or future, are completely and unambiguously determined.*
> *Not a single constituent concept of this Laplacian model of the universe remains unaffected; what has been left intact by the relativity theory was challenged by the theory of quanta or wave mechanics. Relativistically speaking, there is no such thing as a state of the world at an instant; there is no such thing as an instantaneous configuration of particles. Moreover, the concept of immutable and permanent particle, identifiable through space and time, is as obsolete as the concept of durationless instant.*

Milič Čapek, *Philosophical Impact of Contemporary Physics*
(New York, Van Nostrand, 1964), p. 392.

Models can thus obscure the "laws of nature" and impose their own "laws" instead.

Čapek goes on to show that purely visual representations of physical phenomena have so far proved inadequate, and to suggest that:

> *. . . in the temporal structure of the perception of melody, features can be discovered which appear irrational in any visual-mechanical model of physical reality; the primacy of events, the absence of infinite divisibility, the compatability of continuity and individuality, the fusion of becoming with its concrete content . . . such use of auditory models . . . helps to free our mind from the exclusive sway of visual imagination . . .*
>
> Čapek, *Philosophical Impact . . .*, p. 399.

From the above we discern a trend away from rigid, visual-mechanical models towards non-mechanical, other than visual, representations. By continually striving to become aware of their limitations, scientists may be helped, rather than hindered, by the models they create. Identifying ignorance and recognizing necessity are the first steps toward fresh knowledge and to new freedom.

Against the *absolute governance* of laws imposed upon nature by Newton and his successors, other scientists now oppose attempts at *purely objective* description of natural phenomena. By pushing this tendency still further there are many who contend that, so far as science is concerned, "What cannot be measured does not exist", and there are those who insist besides that, "Science has already superseded philosophy".

Nevertheless, both the observer and the observed are interdependent systems, themselves interacting with other perceived and unperceived, measurable and immeasurable, systems of changing systems (often assumed to be closed, for convenience, but always actually open) which together constitute nature. Moreover, even the denial of a role for philosophy itself hides a philosophy. Scientists may thus become not only "blind" philosophers but also "blind" scientists by remaining unaware of the philosophical assumptions lurking in the rules of "normal scientific" procedure, which determine the acceptability of scientific work among professional scientists.

Unperceived environments retarding scientific discovery Scientists, like all of us, are immersed in, and are unconsciously influenced by, the total environment in which they live. Marshall McLuhan continually stresses:

> *. . . the imperceptibility of the environment as such . . . The pervasive structure, the overall pattern eludes perception except in so far as there is an anti-environment or counter-situation constructed to provide a means to direct attention . . . Any new technology, any extension or amplification of human faculties when given material embodiment, tends to create a new environment . . . Our typical response to a disrupting new technology is to recreate the old environment instead of heeding the new opportunities of the new environment. Failure to notice the new opportunities is also failure to understand the new powers. This means that we fail to develop the necessary controls or anti-environments for the new environment. This failure leaves us in the role of automata merely.*
>
> Marshall McLuhan, unpublished lecture notes.

Confronting every scientist, therefore, are problems of becoming aware of, and making allowances for, the effects of his total environment: the biases of his own sensory perceptions, including their technological extensions, as well as the assumptions underlying his scientific theories and methodology. Through conscious awareness of their limitations he can learn to use their potentialities. Moreover, by continually making inventories of the effects of any process upon all observable environments — both "inside" and "outside" his particular discipline — he can learn to accelerate his discoveries; he can also learn by "organizing his ignorance" to make every "breakdown" lead to a "breakthrough"!

In this regard, however, Thomas S. Kuhn contends that progress in science occurs largely in spite of, rather than because of, *normal science*; this, he claims, is concerned only with:

> *. . . research firmly based upon one or more past scientific achievements, achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice.*

Thomas S. Kuhn, *The Structure of Scientific Revolutions*
(Chicago, University of Chicago Press, 1962), p. 10.

Using the term "paradigm" to describe,

> *. . . universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners.*

Kuhn, *The Structure . . .*, preface.

Kuhn goes on to show that:

> *Men whose research is based on shared paradigms are committed to the same rules and standards for scientific practice. That commitment and the apparent concensus it produces are prerequisites for normal science, i.e. for the genesis and continuation of a particular research tradition . . . . . . Mopping-up operations are what engage most scientists throughout their careers . . . to force nature into the preformed and relatively inflexible box that the paradigm supplies. No part of the aim of normal science is to call new sorts of phenomenon . . . .*

Kuhn, *The Structure . . .*, p. 11, and p. 24.

In such a cultural environment scientists unconsciously acquire a criterion for choosing problems that they can assume to have solutions, while taking the paradigm for granted. Problems not covered by the paradigm are then rejected as "metaphysical", or as the concern of other disciplines. Kuhn further points out that:

> *One of the reasons why normal science seems to progress so rapidly is that its practitioners concentrate on problems that only their own lack of ingenuity should keep them from solving.*

Kuhn, *The Structure . . .*, p. 37.

Kuhn then shows that:

> *Discovery commences with the awareness of anomaly, i.e. with the recognition that nature has somehow violated the paradigm-induced expectations that govern normal science . . . until the scientist has learned to see nature in a different way, the new fact is not quite a scientific fact at all!*
>
> Kuhn, *The Structure . . .*, pp. 52, 53.

Thus novelty emerges only with difficulty in opposition to an environment created by normal science, which is the professional concern of normal scientists having normal expectations.

Scientific prediction, quantitative or qualitative We have already achieved considerable success in making scientific predictions by analytical methods, based on arithmetic, mathematical models, and formal logic. We shall now refer to them collectively as *quantitative forecasting* — both extrapolating and interpolating from accepted premises — interpreted and seasoned by human judgment. Where does quantitative forecasting fail?

We cannot adequately describe our actual world of endless subtlety and inexhaustible variety in terms of *absolutely separate factors* undergoing *purely quantitative changes*, as in mathematical models; nor can we reliably foresee and effectively direct the rapidly changing trends of its development through *YES-OR-NO thinking* alone. Today, most of us are also aware of the dangers lurking in quantitative extrapolations beyond what is currently known — no matter how sophisticated our computers may be!

Recently, J. Bronowski expressed our dilemma thus:

> *A. M. Turing in England and Alonzo Church in America showed that no mechanical procedure can be devised which could test every assertion in a logical system and in a finite number of steps demonstrate it to be either true or false. This is Hilbert's* Entscheidungsproblem *in its direct form. In a sense, Gödel's result is deeper than this; and Alfred Tarski in Poland . . . showed that there can be no precise language which is universal; every formal language which is at least as rich as arithmetic contains meaningful sentences that cannot be asserted to be either true or false. . . . . The laws of nature cannot be formulated as an active, deductive, formal and unambiguous system which is also complete. . . . The decision to take new matter into our systems . . . is an imaginative step . . . it is alike in science and literature.*
>
> J. Bronowski, *American Scientist* 54 (Spring 1966), pp. 4, 5, 12, and 13.

Quantitative predictions from known assumptions are restricted by their very nature to defined *properties* — *factors* attributed to defined *things* — in defined *relationships*. Such predictions can therefore tell us nothing about new characteristics and new patterns of behaviour that emerge in evolutionary processes.

We therefore clearly need a technique of prediction that will help us not only to identify but also to allow for the creation of novelty, for growth or decay, for both continuity and discontinuity, and for both *combination* and *separation*, as they actually occur in nature. Such a technique, that we shall now call *qualitative forecasting*, owes its origin to those Greek philosophers who claim that, "Nothing is inevitable but change!" Qualitative forecasting indicates possible trends of development, where certainty is either unattainable or unnecessary; it breaks through the fundamental limitations of quantitative forecasting; and it enables us to make predictions, or constructive speculations beyond formal logic and beyond mathematics — basic tools of science — which are imprisoned in YES-OR-NO thinking.

YES-OR-NO thinking: logic or life Aristotle of Stagira and his disciples based their analytical thinking upon the ultimate abstraction — *pure being* — to which they attributed various carefully defined *properties*, in order to describe separate *things* and distinctive *relations*, which they believed to constitute or to reflect the world. Starting from such assumptions they established rules for *rational thinking* — three axiomatic *Laws of Logic*:

- *Law of Identity* — Everything that is, is.
- *Law of Contradiction* — Everything either is or is not.
- *Law of the Excluded Middle* — Nothing can both be and not be.

We have inherited these modes of definition and laws of logic from Aristotle and have applied them effectively both in quantitative analysis and in mathematics.

However, the implications of these axioms go much deeper: they presuppose that "sufficiently precise" definition of "separate things" and their "specific relationships" would, *in principle*, enable complete description of all individual happenings, here and now. Moreover, "sufficiently complete" knowledge would allow prediction of all future happenings in other circumstances also. This is *YES-OR-NO thinking*.

Quantitative forecasting: extrapolating the known to nonsense For purely YES-OR-NO thinking, *quantitative growth* means increase through simple multiplication or addition. Similarly, quantitative decay means decrease through subtraction or fragmentation.

In the same spirit, *quantitative evolution*, implies the growth of "latent" characteristics from small- to large-scale versions of already created things — man from homunculus. This concept of development, pushed to the extreme, can extrapolate from the known to nonsense! It also suggests eternal repetition: "There is nothing new under the sun." Such is the pattern of evolution for purely quantitative growth devoid of qualitative changes.

This is the conceptal basis for purely quantitative analysis, for mathematical models, and for computer programs, into which we must inject qualitative judgments to determine their specific ranges of validity. Can we foresee the nature, and the timing, of these qualitative changes?

YES-AND-NO thinking: logic and life By treating Aristotle's laws of logical thought as absolute principles to which everything must conform, Zeno of Elea exposed their limitations in his famous paradox of an arrow in flight. Zeno contended that, according to these axioms, the arrow must *either be or not be* where it is (Law of Contradiction). Since it *cannot both be and not be* where it is (Law of Excluded Middle) nor can it *be where it is not* (Reduction to Absurdity), it *must be where it is* (Law of Identity). Therefore, concluded Zeno, all motion is an illusion!

As Heraclitus of Ephesus realized, the Arrow Paradox results from assuming that motion — all dynamic natural phenomena — can be represented wholly in terms of YES-OR-NO choices between definable fixed states of "being". This fallacious assumption has been a prolific source of logical paradoxes and academic hair-splitting, as well as of errors in more practical matters. Heraclitus pointed out that:

> *You cannot step twice into the* same *river, since fresh waters are ever flowing upon you.*
>
> George Sarton, *A History of Science*
> (Cambridge, Mass., Harvard University Press, 1959), p. 240, n. 6.

Heraclitus and his followers, therefore, sought to base their analytical thinking upon identifying various stages in processes of flowing or *becoming*, which they considered as the ultimate abstraction suitable to describe a changing world. Furthermore, by representing *everything as a process in some form of becoming*, conceived as *both being and not being* something — both "environment" and "anti-environment", the opposite sides of some actual process — Heraclitus rejected the Law of the Excluded Middle; he thus denied the axiomatic basis for YES-OR-NO logic and the possibility of maintaining absolute boundaries of any kind in our world. This is *YES-AND-NO thinking.*

NOTES TO FIGURE 1

1 An interaction process begins with its conflicting PRO and CON, which may reach temporary accommodation leading to ultimate decay, if either PRO or CON is suppressed, or which may achieve integration leading to further growth, if both PRO and CON are combined.

2 Whenever a fresh integration is created, another interaction process begins with its own possibilities of decay or growth.

3 The example, shown in brackets, illustrates how conflicting individual and corporate goals may reach temporary compromises by their relative suppression, or may attain ultimate integration through their combined development.

PRO-CON INTERACTION PROCESS

(Achieving Personal or/and Corporate Goals)

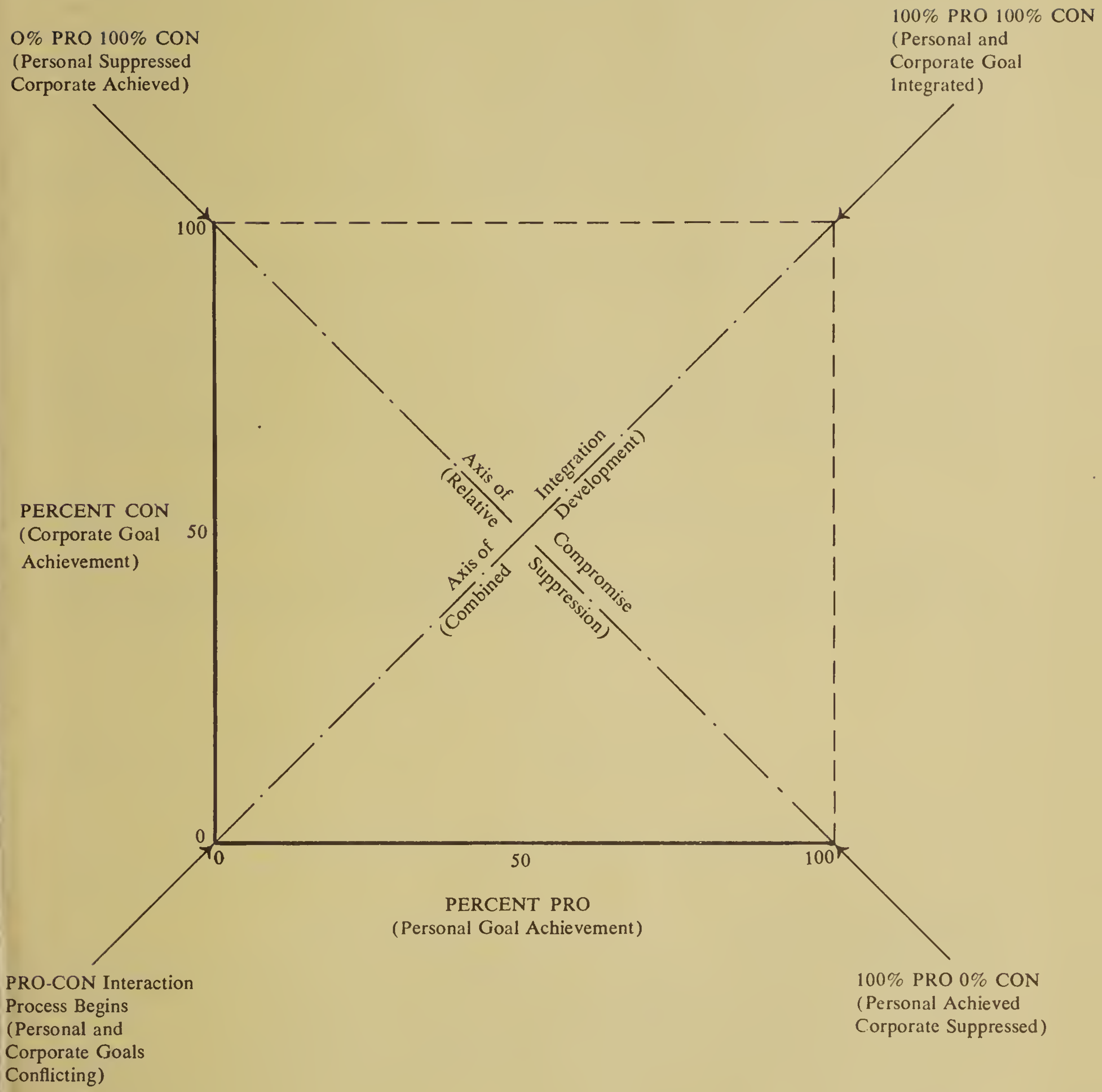

Figure 1

Constructive conflict leads to integration not compromise In practical negotiating we normally consider various tentative solutions, that offer more or less support for some proposal — PRO — at the expense of its counter-proposal — CON — in Figure 1. Such trade-offs constitute varying degrees of compromise. Neither contender is entirely satisfied. Problem-solving and decision making, however, are most fruitful when they succeed in combining opposite sides — both the PRO and the CON — into a fresh synthesis with new possibilities of further development. However, resolving problems in this fashion requires YES-AND-NO thinking, where neither side is suppressed, and both are combined into a fresh unity, that is qualitatively different and that creates something more than a mere conjunction of its opposites. In comparing integrated solutions with compromises, pioneer management scientist Mary Parker Follett remarks:

> *Integration involves invention, and the clever thing is to recognize this, and not to let one's thinking stay within the boundaries of two alternatives which are mutually exclusive . . .*
> *Compromise does not create, it deals with what already exists; integration creates something new . . .*
> *Only integration really stabilizes. But by stabilization I do not mean anything stationary. Nothing ever stays put. I mean only that that particular conflict is settled and the next occurs on a higher level.*

Mary Parker Follett in Henry C. Metcalf and L. Urwick, eds.,
Dynamic Administration (New York, Harper, 1940), pp. 33, and 35.

Centralization, decentralization, recentralization, and redecentralization Business enterprises usually start life, Figure 2, with their decision-making functions

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NOTES TO FIGURE 2

1 Quantitative increases in size of organization require qualitative changes in its structure for continuing growth. Qualitative evolution proceeds through increasingly complex integrations of opposites that characterize every process.

2 By correctly identifying the opposites controlling each stage of process development, qualitative forecasting can indicate their evolutionary trends. These determine the boundaries for valid quantitative projections, which deal with scales of magnitude and rates of change, between trend reversals.

3 A typical example, shown in brackets, is for the birth and growth of a business organized for profit. Optimum rates of integration are achieved by correctly forecasting and stimulating qualitative changes in the evolutionary process.

PATTERN OF QUALITATIVE EVOLUTION THROUGH SUCCESSIVE INTEGRATIONS

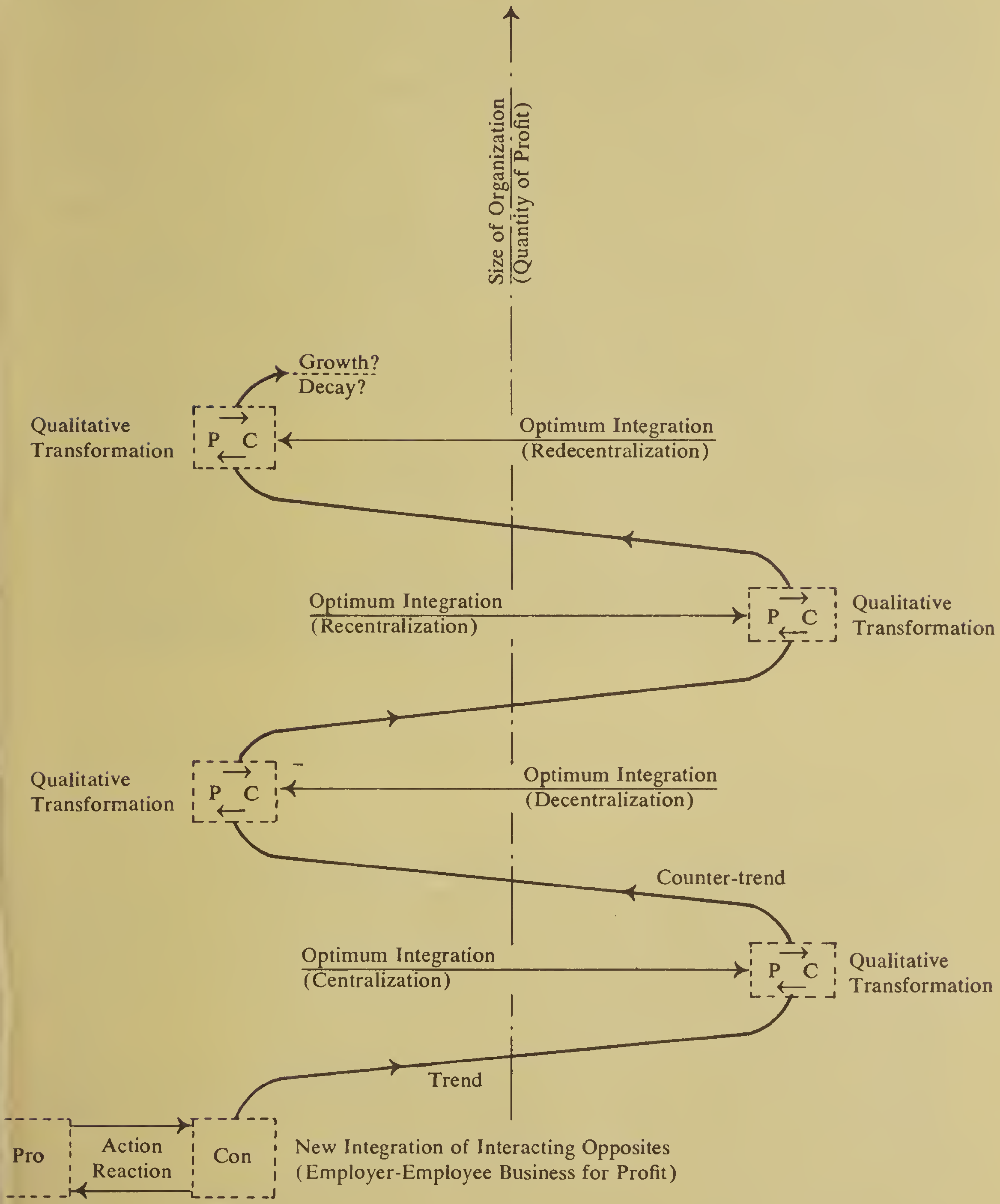

Figure 2

vested in a highly *centralized* authority — most often the owners. As business expands the pyramid of command tends to grow higher and higher.

Nevertheless, repeated experience proves that any large, highly centralized organization, as it continues to expand, will eventually encounter growing obstacles to implementing management policies; intensifying friction in personal relationships; diminishing scope for creativity; and an increasing need for ever greater numbers of still less effective employees. (See C. Northcote Parkinson, *Parkinson's Law* (Cambridge, Mass., Riverside Press, 1957).) Practical requirements for competitive survival will ultimately demand abandoning further attempts to build up centralized authority; remedial measures will then lead to growing decentralization, thereby contradicting previously cherished principles. (See Eugene J. Benge, *Advanced Management* (Oct. 1960), p. 4.)

Nowhere has the tendency to decentralize been more evident than during the growth of international corporations. *Decentralization* has meant intensified delegation of authority to the "field" for day-to-day operations, leaving only major technical and financial, and broad policy matters for "home" office approval. It has also meant adding to the roster of central staff executives. Eventually, clashes of interest between organizational units will multiply to the stage where they inhibit further growth.

By ensuring *more rapid, direct communication* from centres of work to centres of information and direction, improvements in telecommunications, computers, business machines, and other technical devices, eventually permit the structuring of business organizations according to functions and markets, and according to competence and authority, in each operating unit. These fresh technological means provide the basis for a trend reversal toward *recentralization*, that is now apparent in some large organizations, which are both inverting

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NOTES TO FIGURE 3

1 Yes-OR-No thinking implies the possibility of isolating absolutely separate individual causes from their particular effects at each level of organization.

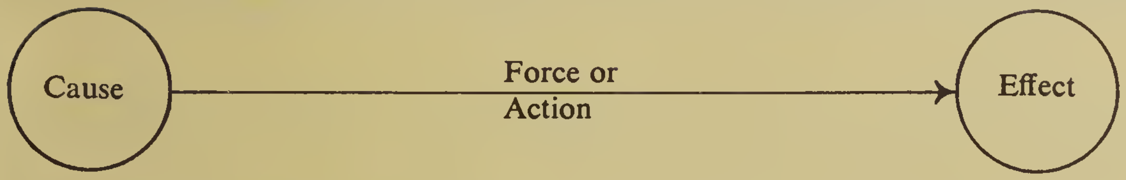
2 Yes-AND-No thinking denies the possibility of absolutely isolating any cause from its effect, and implies not only their direct interaction with each other, but also with a network of interrelated cause-effect processes which may interact less directly.

3 Fresh qualities and new possibilities, for either growth or decay, result from both the changing intensities and the changing ratios of all interacting processes at all levels of organization in the network.

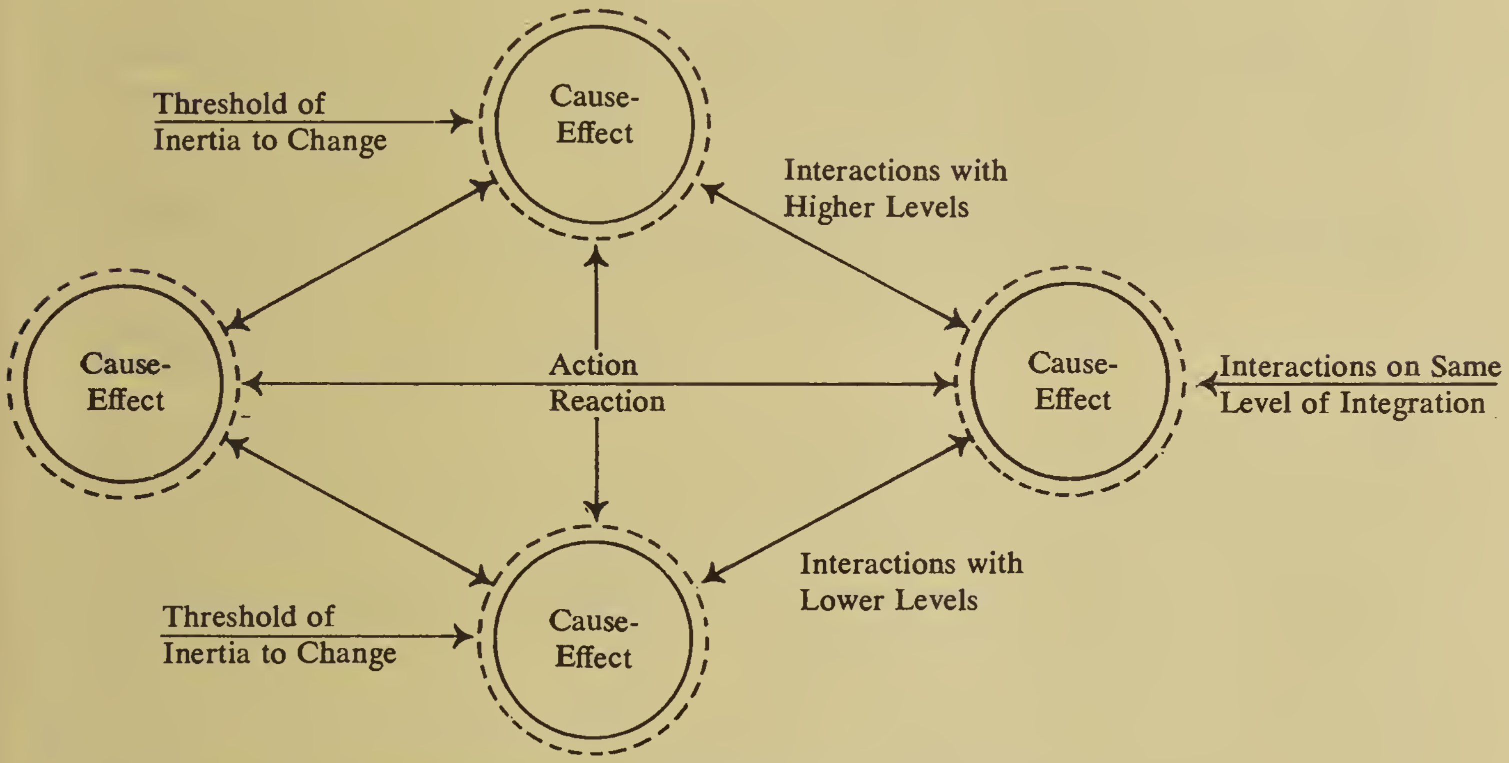
4 The interconnecting lines represent both, new and old, known and unknown but possible, interaction processes, which may be accelerated by juxtaposition and manifested as distinct qualities of behaviour perceived through varying combinations of human senses, with their technological extensions.

5 Concepts are abstracted from the percepts of experience, with their sensory biases in a particular cultural environment, and are continually generalized into "laws", thence into more general theories, which are retested to produce new data and fresh percepts in a never-ending process.

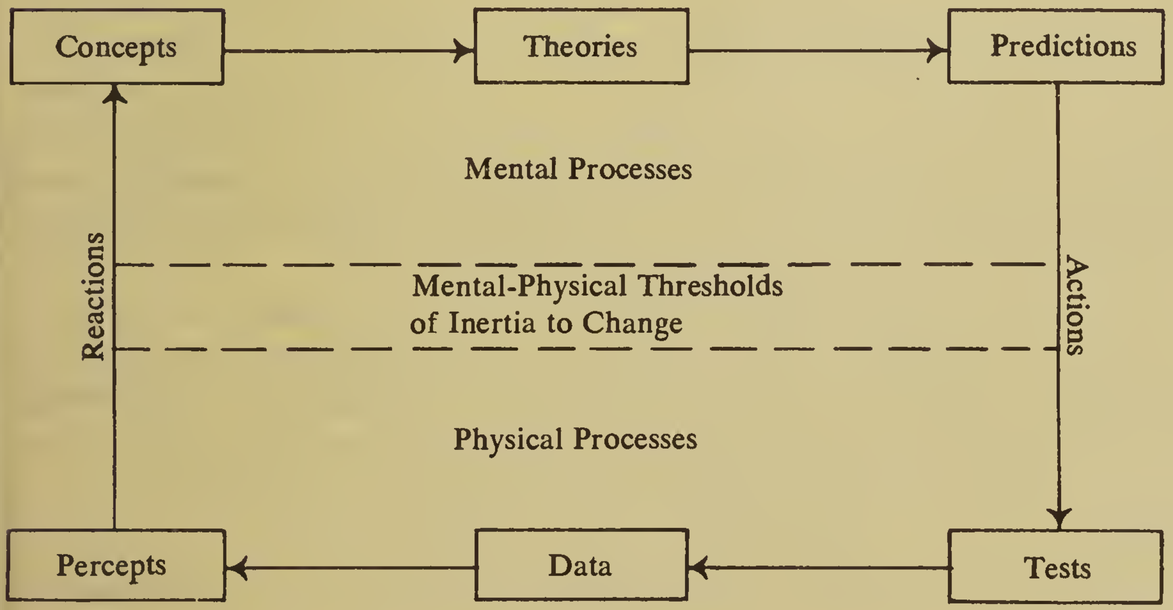
ACTIONS, REACTIONS, AND INTERACTION NETWORKS



3.1 Single Cause of Single Effect through Single Action with no Interactions.



3.2 Multiple Causes of Multiple Effects through Multi-level Interactions.



3.3 Mental-Physical Interactions.

Figure 3

the structural pyramid and reducing its height, thereby contradicting "Parkinson's Laws!"

We can also now discern that such recentralization is generating other problems which, in their turn, will become more complex and more numerous as corporate activities extend through both vertical and horizontal combinations. We may therefore expect and prepare for eventual *redecentralization* (in more sophisticated form than previous decentralization), as a necessary condition for removing future obstacles to further expansion. If decay or catastrophe is averted, oscillations between centralizing and decentralizing tendencies are conceivable in a still more distant future, as communications improve and as systems of organization develop in scope and size to attain and surpass transnational scale — to the transplanetary and beyond! (See Donald P. Kircher, *Harvard Business Review* (March–April 1964), p. 6.) As Marshall McLuhan puts it:

> *An increase of power or speed in any kind of grouping or in any component whatever is itself a disruption that causes a change of organization.*
>
> Marshall McLuhan, *Understanding Media: The Extensions of Man*
> (New York, McGraw-Hill, 1964), p. 90.

Qualitative forecasting: extending the known to reversal and beyond Figures 1 and 2 thus diagrammatically represent qualitative forecasting processes typified by the "management sciences"; with Figure 3 they focus attention on, and they anticipate the consequences of, dynamic interactions in multi-level evolutionary processes with particular regard to *qualitative transformations*, whether perceivable through our senses and their extensions, or only vaguely conceivable in our imaginations. These diagrams predispose us to note the qualitative distinctions in a hierarchy of dynamic physical, chemical, biological, and human organizations constituting our world; they allow for both simultaneous and sequential processes occurring in both separate and super-imposed spaces, perceived through both visual and audile-tactile sensory modes. They suggest dangers of analogy and over-simplification. There are no isolated things, no single causes of single effects. There are only interacting processes. The processes of physics cannot "explain" biology any more than either, or both, can "explain" the behaviour of individual people or their organizations, since these systems of systems, no matter how closely interlinked, are nonetheless open, continually interplaying, constantly changing, and qualitatively different from each other. Such differences are revealed in their distinctive characteristics and patterns of development.

Qualitative forecasting therefore tries to foresee the consequences of extending or intensifying a particular trend, either to ultimate decay or until its counter-trend emerges in a more complex and fresh integration — *qualitative evolution* creating a new environment — and it then attempts to assess the results of further trend-reversals at still higher levels of integration, to the bounds of growth conceivable.

By developing our skill in qualitative forecasting through exploring with it —

by pattern recognition — we shall enrich the "technique of discovery" and the "technique of suspended judgement" described by Marshall McLuhan:

> *The technique of discovery, namely, the technique of starting with the thing to be discovered and working back step by step, as on an assembly line, to the point at which it is necessary to start in order to reach the desired object. . . . In art . . . starting with the* effect *and then inventing a poem, painting, or building that would have just this effect and no other. . . . The "technique of suspended judgement" goes further It anticipates the effect of, say, an unhappy childhood on an adult, and offsets the effect before it happens.*
>
> McLuhan, *Understanding Media . . .*, p. 62.

Exploration means crossing boundaries — both mental and physical — for discovery; it implies juxtaposing the unlikely in order to create the unexpected; it requires interfacing the apparently disconnected to produce often surprising results; and it demands readiness to accept the unique event — the nonrepeatable instance of novelty — which does not fit existing categories of thought or patterns of experience. In this spirit we can also learn to predict the "unpredictable"!

Scientific predicting in future During recent years we have witnessed great progress in the techniques of quantitative forecasting, especially through the development and use of mathematical models and computers. This trend will accelerate; it will increasingly release human brains from the bondage of quantitative calculations, information retrieval, and logical analyses, that computers can do better. Scientists will thus become freer and freer to devote more and more of their time to exploration and discovery through conscious choice rather than unconsciously, or merely by accident! Men will provide the "information" for machines to "deliver the goods"! And "scientists" will become "artists" in Marshall McLuhan's sense that:

> *The artist is the man in any field, scientific or humanistic, who grasps the implications of his actions and of new knowledge in his own time. He is the man of integral awareness.*
>
> McLuhan, *Understanding Media . . .*, p. 65.

Scientific predicting in future will therefore demand growing awareness of what goes on both "inside" and "outside" scientists in their doing and thinking; it will require both quantitative and qualitative forecasting, both visual and audile-tactile models, both YES-OR-NO and YES-AND-NO patterns of thinking; it will explore the interfaces of all disciplines in order to cross their boundaries consciously in search of new knowledge; it will not only make still further use of abstract mathematical concepts but will also draw upon the rich store of artistic and literary metaphors and myths; it will engage in continually making and remaking inventories of everything that the processes studied are actually doing to their environments, in order to determine when trend reversals and fresh patterns of behaviour can or do occur, and how much their outcome is controllable; it will make due allowances for the total effects, not only of the experimental methods and the measurement techniques employed but also of the communication media involved; and it will continually reorganize information both for rapid sequential retrieval — to match the old — and for simultaneous comparison — to discover the new. Nevertheless, scientific predicting will continue to be guided by human "imagination" and tempered by human "judgement", but with conscious involvement of the perceptions needed and with fore-knowledge of their effects. Old sensory modes will be extended and new ones will emerge to create higher levels of human consciousness and broader understanding. Predicting will more and more nearly anticipate the consequences of contemplative actions, while anticipation will evolve into human experience of new kinds — imaginary, privately experienced "present-futures" — converted into social reality through processes that more and more nearly approach total consent, through total understanding, by total communication.

Barrington Nevitt, *Consulting Engineer*